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Psychophysiological Model for the Prediction of Performance

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Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

Abstract

The development of accurate predictors of performance capacity must consider psychological as well as physiological variables. This study attempted to validate the contributions of both of these factors in the prediction of endurance performance. Seven male and female subjects were assessed for their actual maximum oxygen consumption ($\dot{V}O_2$ max) on a treadmill and their predicted max $\dot{V}O_2$ using a submaximal heart rate test on a bicycle ergonometer. A number of psychological instruments were also administered to assess characteristics and psychological states believed to be associated with performance on a distance run test. On the basis of a step wise multiple regression analysis, it was determined that psychological variables accounted for a significant portion of the variance beyond that provided by purely physiological indices.

Key Words: psychophysiological predictor, $\dot{V}O_2$ max, distance run test

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Introduction

The examination of behavior by anything short of a psychophysiological approach is difficult to accept when evaluating physical performance. This is evident when we realize that the physiological capacity of the organism as well as the perceptual and cognitive cues available during exertion are the primary information source for regulating sustained performance. This position is not a new one, yet the fact remains that most research in the realm of physical work or exercise science employs <u>either</u> a physiological or behavioral orientation which lead to conclusions that are both misleading as well as inadequate for the understanding of endurance performance.

In the field of exercise physiology, many attempts have been made made to predict the actual endurance capacity or performance of long distance runners using the physiological measures of $\dot{V}O_2$ max, HR max, or V_E. However, the correlations of these variables with the criterion measure were usually quite poor and highly intercorrelated. This is understandable since all physiological variables respond to the increase in workload in about the same functional manner and capacity is not necessarily synonomous with actual performance. If we selected variables that were not highly intercorrelated with these physiological parameters, and assessed performance related factors we may be able to increase our understanding of, and prediction of endurance performance. Therefore, the purpose of this study was to determine the contributions of both physiological and psychological factors (such as motivation, willingness and perserverence)

associated with endurance performance and to determine if these same factors could be used account for both male and female performance capacity. FIGURE 1.

Method

Seven men and seven women, ages 20-30, received a physical examination and signed a volunteer agreement statement in which the purpose and risk involved in the study were explained. Each subject performed the following tests:

a. A treadmill oxygen uptake ($\dot{V}O_2$ max) test was done following the procedure of Taylor, et al. (4) in which the subject first performed a warm-up run at 5 mph and 0% grade for six minutes. During the last minute of this run, the subject breathed through a large mouthpiece and low resistance breathing valve (Collins Triple-J) and the expired air was directed through 1-1/2 inch diameter tubing into vinyl (Douglas) 150 liter bags. Two bag collections of 30 seconds duration each were taken. Aliquots of each bag were drawn through a paramagnetic oxygen analyzer (Beckman E-2) and infrared carbon dioxide analyzer (Beckman LB-1) to determine the percent fraction of these gases in the collected samples. The total volume collected in the bags was measured by evacuating the gas into a water-sealed spirometer and read to the nearest ten milliliters. The $\dot{V}O_2$ was then calculated using inspired (room air) and expired gas fractions of O_2 and CO_2, expired volume (corrected for temperature and pressure) and expressed in units of liters per minute at standard temperature and pressure, dry (STPD).

After the initial run, the subject rested for 5 to 10 minutes and then performed 2 to 4 additional runs at the same speed but at increasing grades. $\dot{V}O_2$ was measured in each run during the last 45-60 seconds by two

20-30 second expired gas collections. The latter runs lasted for 3 minutes. Subjects were monitored electrocardiographically during all runs. Runs were continued until no further increase in $\dot{V}O_2$ was achieved over the previous load, i.e., VO_2 plateaued with increased work load.

2. The submaximal predictive heart rate test was administered on a calibrated Monark bicycle ergometer using the standard Astrand procedure (1). Heart rate was determined each minute electrocardiographically. The test lasted for approximately six minutes or until heart rate had stabilized between 130 and 170 bpm for the selected workload.

3. A battery of psychological tests were administered to assess intrinsic factors which may be predictive of performance capacity but have heretofore been considered uncontrolled error variance. The measures included were the Eysenck Personality Inventory (EPI) which consists of measures of introversion-extroversion, emotionality and psychometric ~~motivational~~ distortion; a scale that assesses the tendency to distort responses to meet the expectations of the investigator or situation. The Edwards Personal Preference Schedule (EPPS) subscale for endurance which assesses willingness to continue a job until completed.

4. The distance covered during a 12 minute run test was used for the assessment of endurance performance of each subject.

5. The data were analyzed using a stepwise multiple regression program (STEPREG 1).

Results

Means and SD for the variables are presented in Table 1. T tests demonstrated significant differences between the male and female $\dot{V}O_2$ max values and the distance covered in the 12 minute run test. A stepwise multiple regression of the predictor variables against the criterion yielded significant F values (p<.05) for the male and female subjects and are presented in Table 2. The correlation of the men's $\dot{V}O_2$ max (.897) and the predicted $\dot{V}O_2$ max for women (.912) with the distance run test were quite high. However, for both groups the multiple R (.97) achieved when the analysis incorporated the psychological variables demonstrated a significant improvement over that found when only the physiological parameters were used for the prediction of endurance performance. The endurance score played a substantial role in the prediction of men's performance. It did not enter into the equation for the prediction of the women's performance. However, response distortion along with the predicted max values were responsible for most of the performance variance for women.

Discussion

Despite the relatively small number of subjects per variable (4:1) it can be seen that use of physiological factors alone have a sizable correlation with endurance performance. However, the psychological measures of endurance and response distortion also account for a significant portion of the remaining variance i.e. 14 and 11% for men and women respectively. This is important for more than merely its statistical significance. The relationship between psychological factor and endurance performance has always been assumed to exist by coaches and athletes alike, yet has not had much documentation in the scientific literature. This is understandable because of the relative insensitivity of many of the psychological instruments to transient cognitive or perceptual factors that may affect performance. However, a physical task, such as endurance performance or sustained work is ideal for this sort of investigation. When dealing with an energy system (man's physical abilities) that is subject to a decision making modulator (the brain) it is the latter which determines the mobilization of the energy system and, as all good coaches know, must be prepared if a sustained near maximal performance is to be expected. It is noteworthy that the variables of endurance which played such an important role in the prediction of men's performance did not enter the predictive equation for women. This can be explained by accepting the fact that untrained women do not have an accurate perception of their physical performance capacity or their ability to sustain a prolonged

physical effort. More important for the prediction of women's performance is their willingness to meet the expectations of the experimenter (or coach) whether these expectations are subtle or explicit. The coach can readily appreciate that the prior competitive experience of an athlete, whether male or female, requires a different approach to optimize their performance. This may be due to the development of different cognitive strategies to cope with sustained exertion or the development of perceptual cues used to focus attention on factors or physiological responses i.e. skin temperature, respiration rate, pain or stride length, or lap time, that they believe provides necessary information to adjust or maintain their performance level.

World class marathon athletes have reported a wide diversity of cognitive strategies and cues that they use to facilitate their performance.[3] The important element here is not what technique is used but that the cognitive component is important in the control of the athletes performance.

The intent of this paper was to point out the fertile area for investigation that has been opened by assessing psychological factors in endurance performance. If these findings can withstand the test of replication and other psychological components can be identified, we may be able to use them to, not only predict performance, but also as techniques to extend endurance performance.

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TABLE I

Summary of Descriptive Measures and Significance Test (N=14)

		Male	Female	T Valus
$\dot{V}O_2$ max ml/kg/min	$\bar{M}$	49.67	39.24	4.29*
	SD	5.21	3.77	
Predicted VO_2 max		36.32	37.92	
Astrand-Rhyming		7.76	3.57	.50
Endurance (EPPS)		7.00	6.86	
		1.82	1.57	.15
RESPONSE DISTORTION ~~Social Desirability~~ (EPI)		2.14	3.57	
		1.30	1.90	-1.65
Distance in 12 min run		1.31	1.09	
(miles/nearest 55 yd segment)		.24	.09	2.27*

TABLE 2

Summary Table of Multiple Regression Analysis of
Predictor Variables Against the Performance Test. (12 min. distance run)

Males

	Coeff of Multiple Correlation	Coeff of Deter. R^2	Change in Coeff R^2	Sign. Level of F Value
VO_2 max actual	.897	.805		
Endurance (EPPS)	.9743	.949	.144	.028*

Females

	Coeff of Multiple Correlation	Coeff of Deter. R^2	Change in Coeff R^2	Sign. Level of F Value
Predicted VO_2 max (Predicted)	.912	.832		
Response distortion	.9744	.945	.117	.038*

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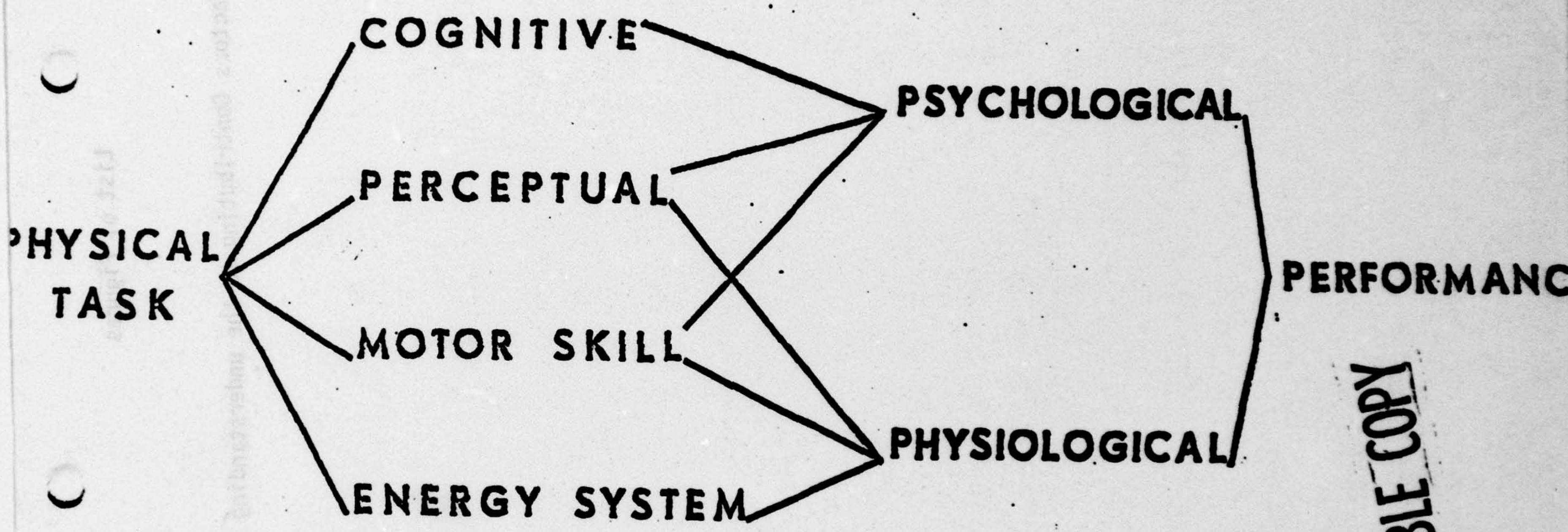

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